



UNIVERSITY OF GOTHENBURG



Using Mobile Phones To Assist Children's Learning In Universeum

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ABSTRACT

This master thesis study explores how to assist children's learning using mobile phones in Universeum located in Gothenburg, Sweden. Universeum is the largest Science center in Scandinavia where children can learn the ocean, explore rainforest and discover space. From the field study carried out firstly in Universeum, some findings are gained, for example children prefer to discuss and share their findings with their friends, classmates or family members; children use body gestures to describe some animals; children are interested in big and colorful animals; children would like to capture some photos using their mobile phones and share their photos with others; children are interested in viewing photos captured by others. A system, which includes a mobile application and a web portal, is designed based on the review of the related work and the data from the field study. A prototype of the mobile applications is built and named Fotofiske which includes some information of exhibitions in Universeum and children can take photos using their mobile phones to match specific exhibitions' information. Finally from a small evaluation of this prototype in Universeum, there are some findings about how to improve this prototype and deploy it at Universeum. For example children think that Fotofiske is interesting and fun. It is better to publish the Fotofiske game at the Universeum web site and let children freely download it before visiting. From this study, it reveals children can use mobile phones to gain knowledge at Universeum. The mobile prototype enables children to learn in a more interesting and interactive way at Universeum.

AUTHOR KEYWORDS

Children, mobile phones, museum, photo, camera phone, interaction, mobile game.

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1. INTRODUCTION

Mobile phones are becoming necessary devices in our everyday life. They are easily carried and used. At the same time, more and more children own mobile phones, so an increasing number of attentions were paid on the mobile phone use of children. For example, a study focusing on mobile phone use among children in playground has been carried out by researchers in Sweden [11]. Apart from the common usage, mobile devices (such as mobile phones and Personal Digital Assistants) can also be used to support children's learning. Children can carry their mobile devices to anywhere and use them at anytime. Lots of applications running on mobile devices have been developed for assisting children's learning [5, 10, 15].

How can we use mobile phones to help children to gain knowledge in an interesting way? When considering this question, museums come to my mind, as museums present different kinds of knowledge in a vivid way, which could promote children's learning and increase interest of the learning process. Dewey wrote "the central problem of an education based upon experience is to select the kind of present experience that lives fruitfully and creatively in subsequent experiences" [8]. Furthermore Csikzentmihalyi and Hermanson mentioned in their discussion how "one often meets successful adult, professionals, or scientists who recall that their life-long vocational interest was first sparked [as a child] by a museum" [7]. Researchers also pointed out that "Museums are among our pre-eminent cultural institutions for learning. Museums are where society gathers, preserves, and displays visible records of social, scientific, and artistic accomplishments; where society supports scholarship that extends knowledge from paleontology to meteorites; and where people of all ages turn to build understandings of culture, history and science." [13]. Therefore, museums are attractive and interesting places for children where they would like to spend lots of time. In museums, there are diverse kinds of knowledge. Thus it is quite valuable to make efforts to think about using mobile technologies to make the learning process in museums easier and more interesting. Lots of projects have been carried out using mobile devices (such as PDA or mobile phone) to help visitors to learning in zoo or museums in a more fun and easier way [1, 4, 6, 9, 14, 17, 21]. Considering the facts above, a question is arising. How to use mobile phones to assist children's learning in museums in a new way?

This master thesis study aims to explore how to use mobile phones to help children's learning in an interactive way when they are visiting museums in a new way. The target users of the project are children in primary school, aged from seven to twelve or even younger children from four to six years old who can manipulate mobile phones with the help from their parents. In this project, some initial field studies were carried out at Universeum in Gothenburg of Sweden. According to the outcomes from the field study and a review of related works, a system is designed and a mobile phone game application is implemented to assist children to learn from visiting Universeum. This application will let children not only walk, listen and watch exhibitions, but also interact with the environment of Universeum. In this way it can help children to learn and bring them more fun. The mobile application tried to build the interaction among children, mobile phones and Universeum (Figure 1). Mobile phones store information about exhibitions of Universeum; children get information from both mobile phones and Universeum; children take some photos of exhibitions which are related to information in mobile phones.

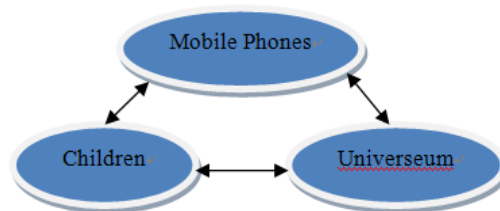


Figure 1.The relationship among the three main entities in this project.

The expected outcome of this project is to design a system to let children learn by taking and sharing pictures of exhibitions in Universeum and implement the mobile application part.

This thesis is organized as follows. The second section will present the literature review which includes four different areas related to this master thesis study. The four areas are the mobile phone use of children, the experience of children in museums, the camera phone use of people and a review of current mobile

devices used in museums. The third section will present the field work carried out at Universeum of Gothenburg in Sweden which is the target using environment. It includes the approach of how to carry out the field work, the basic information of Universeum, some typical raw data, the data analysis and the main findings from the field work which can be valuable for the design of the system. The fourth section will describe the system design and the mobile application's requirements based on the literature review and the field work. In the fifth section the implementation of the system is introduced. The sixth section will present a short evaluation of the mobile application (Fotofiske) which was carried out at Universeum. Some discussions about the whole study will be introduced in the seventh chapter. The result of this study is presented at the last section.

2. RELATED WORK

This master thesis project is aimed to design and implement an application running on mobile phones to assist children's learning in an interactive and interesting way in museums. The literature review is focusing on children, mobile phones and museums and their relationships. In addition, a short review of the camera phone use will be presented, as the general idea behind this mobile application in this master thesis project is to use the camera function of mobile phones. Thus in this chapter, firstly it will look into the usage of mobile phones among children. Then secondly it will introduce some common children's experiences at museums. Thirdly, it will describe camera phone usage. At last, it will introduce some projects in which mobile technologies are used at museums.

2.1 The usage of mobile phones among children

Lots of children own mobile phones. How do they use them? What kinds of functions do they often use? What kinds of activities can they do by using mobile phones? A study of mobile phone usage among 10 to 12 years old children in casual play settings has been carried out by other researchers in Sweden. [11] The study was taken place at the "Parklekar" which is a kind of 'play center' in a park. In the "Parklekar", there are outdoor playground equipments and indoor facilities. Children can do lots of activities inside of the "Parklekar", such as painting, playing games, doing carpentry, doing homework. There are also some employees who can help children with planning and managing some activities.

In this study, researchers did some observations and group interviews at the "Parklekar" and found out some most frequently used functions of children in this casual play ground:

"Making phone calls and sending text messages" [11]: from the interviews, the researchers found out that the children used their mobile phones mainly for contacting their parents and almost all of the call communications are with their parents. This is the main reason that their parents gave mobile phones to their children. The text message function was frequently used with their friends and parents. Besides the common usage of the call function, children also used the call function in play game activities. For example, a group of girls used their phones in playing 'cops and robbers' which was played both in outdoor and indoor. They used video calls in group to display where a competing peer was heading. From interviews, some children said they also used the ringtones of the mobile phone in the outdoor games. For example, a child called an enemy's mobile phone and then the child could find the enemy's place by the ringtone of the enemy's mobile phone.

"Taking pictures, recording sound and video" [11]: almost all of the groups of children used these functions. For example, they used mobile phones to take some funny photos and to use them to make their own short movies, commercials or music videos. The activities in which these functions were used brought lots of fun for the children. Furthermore using these functions were some kinds of play activities of their own. They also used the taking photo function of mobile phones to play a game called 'photo war'. The children were in two teams, which are girls' team and boys' team. Each member tried to capture a photo of the competing team members by mobile phone. Both team members tried to avoid to be captured by the competing team members, so they had to move and spread most of the times. As the cameras of mobile phones were quite sensitive, it was very hard to take a very good quality photo. After the playing the children got together and discussed and evaluated the photos they got. Then they compared which team had more good pictures.

“Playing music and video” [11]: during observations, the researchers found that children often got together and shared videos, pictures or music with each other (Figure 2). These shared media were about some experiences they did together in the group activities but not something someone did individually. Children also found out some creative ways to interact with these media content. For example, two children used their own mobile phones to play a same tune at the same time and the challenge in this activity was to try to play the same song in the two mobile phones simultaneously.



Figure 2. The children assembled to share some media. [11]

“Transferring files (using Bluetooth and IR)” [11]: transferring files within groups or among friends was another frequently used function among these children. They usually transferred a tune as ‘gift’ to each other. By discussing and analysis the transferring history of some tunes, it could reveal some social relationship among these children. Furthermore, during an interview, two boys mentioned that some music tracks, which were downloaded through some prepaid services, could not be transferred. They tried sometimes and it was fail to transfer that kind of music tracks.

“Other functionality (e.g. downloaded software)” [11]: from one focus group interview, children mentioned a popular mobile phone game which they played almost every day in summer and it was called ‘the camp game’. This game was software which was downloaded by one child into his mobile phone. The software was related to modifying some camera images and the things moved in the images became white. When playing the game, only this child had the software in his mobile phone and other children did not have that software in their mobile phones. However the group game activities could be carried out very successfully among the children.

From the findings above, we can see that besides making a call and sending a message, children can manipulate mobile phones to do lots of things such as taking photos, recording video, downloading files from web site and transferring files. They also can use these advanced functions in their play activities. Basing on this finding, it possible to use mobile devices to help children gain some knowledge while playing.

Another study has been carried out in Sweden which focuses on using and sharing mobile phones among teenagers in the local situation [18]. This study reveals that mobile phones are not only tools for communicating with dislocated others, but also tools for local social interaction. Mobile phones are shared in mainly two ways. Firstly, teenagers share the content or information on mobile phones without sharing the phones themselves. For example, teenagers share their SMS-messages by reading the message aloud or by showing the display of a mobile phone to others. Secondly mobile phones are often shared and handled by more than one person. As we will see in the third section of the thesis, there are similar findings in my field study, that children (5 to 12 years old) share the photos with others.

2.2 Children and Museums

Museums are very good informal environments for children’s learning. They have a great influence on children’s motivation and interest in learning. [7, 8] Museums can provide different kinds of knowledge for children such as materials of diverse cultures, knowledge about history, science or nature. [13]

This chapter will present one study which has been done by other researchers, aiming to find out the nature of children learning through museum experiences and the study was carried out in four different kinds of museums [2]. It was conducted in a natural and social history museum, an art gallery, a science center and a hybrid art/social history museum. In this study, the researchers did some observations and interviews with children to find out their experiences and their interpretations of these museums. Some outcomes were found described as follows:

Children's interests and impressed exhibitions in the museums are quite different: during interviews, children were asked to recall any experiences or aspects of their visit in the museums naturally without the interviewer's stimulus or prompting. The researchers also asked the children to describe the most favorite exhibitions of the museums. The answers of the children showed that they have predominantly different impressed exhibitions and diverse enjoyable exhibitions.

Large-scale exhibitions are easily to be remembered by children: from observations, the researchers found that children were more interested in and attracted by large-scale objects and exhibitions. During group interviews, children usually recalled and described their experiences with large-scaled exhibitions. For instance, children frequently mentioned the dinosaur models and whale models in the natural and social history museums; they also described the big magnet wall which could be manipulated in the art/history museums several times in different groups.

Introducing exhibitions by a story-telling way can leave a deep impression for children: in group interviews with children, they preferred to recall and mention some museum experiences which were introduced to them by a kind of "story-telling" way. For example, in the art or social history museum, a class of children sat together in front of works of art and then they took part in a facilitated discussion, viewing and critiquing art which were leaded by their teachers or the staff of the museum. Researchers thought that hearing stories or reading stories from books were the common, familiar and enjoyable way for children to gain knowledge in their everyday life, so the phenomenon from the interview correctly matches the familiar learning way of children.

The theater-based programs were vivid and could be understood and remembered easily by children: from the data of interviews with children, it showed that interactive and live presentations in the theatre left deep impression for children. For instance, an "Unexpected Science" show demonstrated lots of strange science phenomenon and organized a discussion with children about the experiments in the science center; there were also presentations about the history and natural environment using interesting slides, which included pictures of animals and dinosaur models and collections from field works, in the theater of the natural and social history museums. To make the presentations more attractive, a lot of stories about the museums and the exhibitions were also included.

There were tenuous links between the experiences in museum and the knowledge learned in the school environment: there are pre-visit and between-visit classroom sessions to find out the connections between the experiences in the museums and the knowledge they learned in classroom. A researcher and a school teacher collaboratively managed these sessions and introduced some information about the museum (using pictures and other theory based activities) to children. From the analysis of the data from the interviews, researchers found that it was not so common for the children to connect the experiences from school to museum. However there are still a little successful examples in this study. In the classroom sessions for two schools, there are specific and directly related content process and vocabulary about the museums were introduced to children before they went to. It showed these children could link the knowledge in the classroom and the experiences in the museums.

The content and the format of the exhibitions in museums have a strong influence on the children's visiting process: from interviews, researchers found that the exhibitions in natural and social history museums and in the art/social history museums were more easier for the children to understand and be interested in than the exhibitions in the art gallery and the science center. The children were excited with the exhibitions in the natural and social history museums and in the art/social history museums, as the exhibitions there were related with some experiences in the children's common life. For instance, there were preserved animals, dinosaurs and vehicles in the natural and social history museums and the related knowledge about these exhibitions can be accessed by children through their toys, story books, popular media and school environment. However the children may not be familiar with the art concepts or science phenomenon in the art gallery and science center, so it is better to make the exhibitions in these museums

to be readily accessible and build the familiar links for children. For example, there are some interactive places in the science center to engage children to participate in the play based activities in their familiar way. Form this study, it showed that these interactive spaces left a good impression for the children.

The finding in this study gives good implications for the design of the mobile phone application in museum, for example, focusing on large exhibitions, making the application more interactive, and designing the application in a learning way familiar to children.

2.3 Mobile phones' photos technology

The general design of the mobile application in this master thesis project is using the camera function. Children will use their mobile phone to capture a photo of fishes in Universeum as an answer to the questions which described in an application running on mobile phones.

In this paper, authors describe some situations in which people often took photos, the intent of taking these photos and the usage of the photos [12]. From this paper, it reveals people often use images in camera phones for social and personal purposes and for affective and functional purposes. Using the data from two sources (interview and images collection), the researchers classified the images into six categories according to the different intentions behind the captured pictures (shown as Table 1). In the Table 1, 295 images were used, and 22% of these photos had more than one intention, so one image could be filled into multi-category.

	Social		Individual	
	Description	No. of images	Description	No. of images
Affective	Mutual experience.	103 (35%)	Personal reflection.	120 (41%)
	Absent friends or family.	63 (21%)		
Functional	Mutual task.	11 (4%)	Personal task.	29 (10%)
	Remote task.	23 (8%)		

Table 1 category of the images by the intention (adapted from [12])

The first big category of images is captured as affective reasons:

Researchers found out people often took photos using camera phones for sentimental or emotional reasons. From the figure in Table 1, about 97% of images are captured for affective reasons. For instance, someone who took a picture just wanted to joke or show affection for the others or looked forward to someone else's emotional reaction. This big category could be divided into three small categories in detail which are "mutual experience", "absent friends or family" and "personal reflection", described as following.

Mutual experience: the most social reasons to capture photos were aimed to enrich the mutual experiences by sharing photos with people who also presented the event taken place. This kind of images is often captured at social or public place, for example, pubs, playground or restaurants. People shared with the images immediately with the people at the taken place or shared with others later as a memento. In the first primary situation, the photos captured were mainly for sharing with people who presented the place at the same time or immediately to enhance a social occasion, to mark an event or to describe the value placed on an experience. Even sometimes capturing photos was the social end in itself. The purposes of taking this kind of photo are joking and gentle provocation or just to celebrate getting together. For instance, an interviewee who took a photo of her friend just wanted to "embarrassing her childish friend" who was busy making a parachute out of a plastic bag (in Figure 3 a). At the second main situation, people captured and shared images with others as mementos and this kind of photos is usually shared later with other people. For instance, a photo of a bride-to-be was taken as memento of her "hen night" in Figure 3 b. The usage of this kind of photos is not straightforward. Most of the time, people shared the images in the moment.

Absent friends or family: this kind of photos is captured to share and communicate experiences with other people who did not present at the event taken place. Photos in this category were mainly about specific things and people that had shared meaning with the absent persons. They shared the photos in the moment or later. For example, a person shared a photo which she captured of her muddy boots at a music festival and then sent it to her absent friend by sending a MMS (Figure 3 c). There are also images taken to share

specific experience with other people. For instance, a woman took a picture of a riddle concerning a gift and sent the image to her husband (Figure 3 d). In addition, people also used camera phones to make a contemporaneous connection with others to let them feel as they are present at the place. For example, one subject said he used his camera phone as a “telepresence” and tried to make his absent girl friend as if she were “here to see it”. Images sent to friends in the moment were trying to make the people’s friends have the ongoing conversational context. In addition to this, people also shared images later with others who were absent by sending the image from mobile phone, sending images through email from a PC, posting some images on a web page or printing the images and then mailing them in a letter. The person who shared images later typically wanted to tell a story to the absent friends or family.

Personal reflection: people captured some photos for their personal reflection or reminiscing. During interviews, some subjects pointed out that the good aspects of camera phones were portable and could be used to capture and store images. For example one interviewee said: “It’s nice to capture a little moment to carry with you. It’s a memento.” In this way people can carry their favorite images or keep their treasured persons’ or objects’ photo in the camera phone. For example people could store a photo of their family, friends, pets or gifts for the emotional reasons. In addition there are also some images stored for some personal and private reasons. For instance, a woman stored a picture of a favorite house she wanted to own (Figure 3 e). Although photos in this category are firstly captured for a person’s individual reflection, around 80% of them are shared with other people through mobile phone or PC.

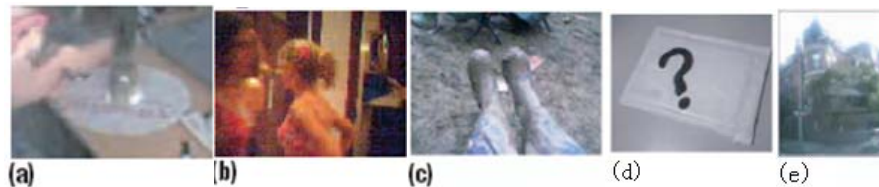


Figure 3. Images captured for affective reasons. [12]

The second big category of images is captured for functional reasons:

Comparing with three kinds of affective images mentioned above, functional photos are more practical and they are captured and used for specific tasks.

Mutual task: There are only 4% of the images in this category. Half of these photos were taken by people to test the camera phone’s functionality, another half of these images were used to be shared with other presented people and to finish more substantial tasks. Some images were used as a sharing record to help people to describe something more carefully and fully.

Remote task: this kind of images is used as a part of a task and shared with other people who were absent at the captured place. Most pictures in this category were about particular things related to the task. A person also used an image to describe or remind a remote person about something they needed to do or used it to discuss something with a remote person. For instance, a subject sent a photo of a goldfish to his daughter to remind her to feed the fish at home when he was away. Another usage of this type of images is to prove to absent people about a fulfilled commitment. For example, a subject who was looking after his friend’s dog took a picture of a dog to show his friend that the dog is very healthy, when the friend was away.

Personal task: Images are used for some practical and personal tasks. Around two-third of images in this category are about particular things related to a task. Lots of subjects record information using images for the later usage as references. For instance, a woman took a photo of a gift idea while she was shopping. Some images also used as a reminder, for example, a youth captured a photo of his friend to remind him to send a message to the friend.

This study reveals people usually sharing images with others naturally. In this study, two third of the images were taken for sharing with others and primarily for affective reasons. In the sharing process, most of them were shared among people face to face. Secondly people used captured images to communicate with remote people to bring them to join in the experience happened in the moment or to collaboratively finish tasks with them. Finally as people could use camera phones to take, to store and to view images anywhere they want, lots of subjects used camera phones as a flipbook of images or used them to record information for supporting task-related functions or to build individual reminders.

2.4 Mobile devices used in museums

As the goal of the master thesis project is to design a mobile application for children's learning in museums, I surveyed some studies which are focusing on using mobile devices (PDAs or Mobile Phones) to assist people's learning in museums

Firstly some projects have been done by using PDA to support children's learning in museum. They are all designed in the question-answer form, but the details are different. Some of them are 'puzzle' based games and some of them are designed in multiple choice form and some of them have an open-ended question which do not expect a correct or fix answer. Secondly, two systems aimed to assist people's learning and to make people easier to get some information from the museum are introduced. These systems are more like a digital guiding system for museums using mobile phones or PDA and cameras. Images are used in these two systems either by taking a photo of a 'visual code' of an exhibition or by capturing a photo of the exhibition. At last, a comparison of these six systems will be described.

There are the four learning systems in museums firstly.

System one: a question-answer based learning system using PDA [21]

Musex is a system to help children to learn and explore collaboratively in science museums using PDAs (Personal Digital Assistants). [21] In the Musex, there are questions related to the exhibition and children collaboratively challenge the questions. In this way, children can focus on the exhibition and get to know the content naturally. Musex is designed to be used in pairs, for instance, friends, brothers or sisters. The system overview is shown in Figure 4. There is a RFID (Radio Frequency Identification) tag in each exhibition of the museum and each of these tags has an ID number. In each PDA, there are a RFID reader/writer and a wireless LAN card. The RFID reader/writer can identify exhibitions by the ID number of the RFID tag in each exhibition. Then the PDA downloads the corresponding questions according to the ID number from the Database Server through the wireless LAN card. The Database Server stores all the information about the questions and answers for each exhibition. Then the user read the question of the exhibition and four choices answer to the question of the exhibition and select one among these four choices by touching the corresponding button. After that the answer of the user selected is sent to the Database Server and the Database Server checks if the user selected the correct answer and then sends the result back to the PDA. After that on the screen of the PDA, it will show "Correct Answer" or "Wrong Answer". At the same time it shows some explanation to the question.

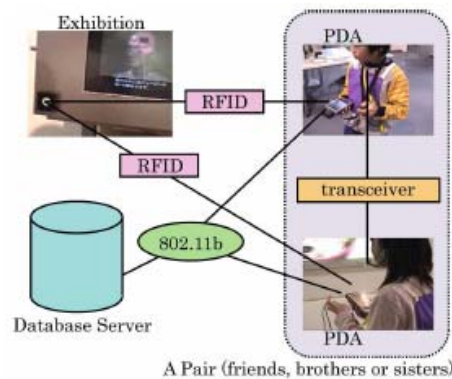


Figure 4. System Overview [21]

System two: a learning system with an open-ended question; using mobile phone to collect data as answers.

MyArtSpace is a learning system for children when they are visiting museums [17]. In this system, there are two parts. One program runs on mobile for a child to collect materials that are related to the open-ended question assigned by the teacher and then build a gallery of his own; another part is the web site part which lets the children to view their gallery, share it with teachers, classmates or family and use it for some other learning process after visiting a museum, such as presenting it in the classroom. The mobile part of the system supports the students to make their own interpretation of the museum by describing the objects, images and sounds. Each student is equipped with a multimedia mobile phone which is Nokia 6680. Every

student also has an identifier in the Web portal. When a student finds an exhibition which is related to the open-ended question assigned by the teacher, he can enter the code of the exhibition to the mobile phone. Then a multimedia and a text description of the exhibition are sent to the mobile phone and at the same time a picture and a text description of the exhibition are also sent to the student's own collection area in the Web portal. The student also needs to write the reasons for the picture and the description to mention why this exhibition can be used as one of the materials to answer the open-ended question. The student is also informed about the names of his classmates who also collect this exhibition as materials. In this way the student can find these kinds of people to communicate and discuss about this exhibition after a while. Apart from the image and the description provided by the museum, students can also collect their own materials to enrich his collection area on the Web portal. Students can use mobile phones to take photos, to record sounds or to write text comments for the exhibition and then sent them to the Web portal through the system. After visiting the museum, in his own collection area on Web portal, a student can view some materials collected himself and some images and description sent from the museum. Then the student can manage and use all of the material to build his own gallery, to present them in the class or to share them with his family. A student can also view some collection of his classmates.

System three: a learning system with different kinds of question-answer forms; using PDA.

Another multi-device environment to support multi-visitors interaction and cooperation in museum through games is designed and implemented [9]. Users can both individually and cooperatively participate in the game. In this system there are mainly two parts. One is an application running on PDAs and the other is a system on a stationary device with a public display. The mobile application on PDA provides the user different kinds of questions about the artworks in the museum and lets the user answer questions individually. There are five types of the questions regarding the artworks of the museum, such multiple choice questions, association games (for example built the association between authors and artworks), detail games (guess which artworks the detail is belong to), ordering the artworks by the date of execution and guessing a word according to an image of an artwork. The system in the stationary device connects to a large share screen. In this system there is a social game which contains a series of questions around a topic associated with a picture of an artwork hidden by an overlaid jigsaw puzzle. This puzzle is related to the individual game in the PDAs of the team members. When each team members correctly solved one question in his individual PDA, one piece of the puzzle will be removed and then small part of the pictured can be seen. The question answered correctly by a team member will not be shown again on the other team member's PDA. Through this way, the team members can do some jobs individual and collaboratively. It can promote the users to participate in as group and have more fun.

System four: a question-answer (puzzles form) learning system; using PDA.

"Mystery in the Museum" [6] is another collaborative learning system designed for historical or cultural museum using PDA. Students are organized in groups collaboratively participating in the activities which are based on a "Mystery in the Museum" story. The application on PDAs is designed as puzzles which are related to the exhibitions of the museum. These puzzles are implemented in two forms which are text puzzles and image puzzles. In the text puzzles game, students have to use the different pieces of texts to compose a manuscript of the museum. Different groups of the students only receive a subset of verses which belong to a poem. The student firstly should find the manuscript which the verses are belonged to. Then they should put the verses in the correct order. As each group of children only receive a subset of the verses, they have to go exchange the verses with other groups to gain all of the verses and then put all of them in the right order. The image puzzles are pictures of exhibitions. Each group of the students has a set of picture pieces which are belong to different images of exhibitions, so they also have to exchange the pieces of the images with other groups to gain all of pieces of a particular one image of an exhibition. After an individual puzzle solved, a clue of the mystery is give to that group. When all of the clues are gained, all of the students get together and discuss about the different clues and then they can rebuild the story and try to solve the mystery.

Secondly there are two digital guide systems which use camera phones or cameras.

System five: information about an exhibition was provided by capturing a photo of the visual code of the exhibition using camera phones. [14]

The prototype of the system, uLearn[14], is designed based on using Smart phones and visual codes technologies to support children to learn independently in a museum or in a park environment. To use this system, every exhibition of museums or every small animal in the indoor or outdoor environment in zoo should have be equipped with the visual codes on the label of the exhibitions or on the introductions or descriptions of the animals. For example, the visual codes are shown in the circle in Figure 5 (left one). Children can use their smart phones' camera to take a picture of the visual code on the label of the exhibition or the animal. Then the visual code is sent to the web server which can analyze and recognize the visual code and then retrieve the corresponding multi-formed information about this exhibition or animal. These multi-formed of information are then sent to the smart phone of children. The system's overall architecture is shown in Figure 5 (right one). The form of the information includes text, pictures, audio and video/animations. The content of the information could be the name of the animal, the animal's ecology and habitat or the sounds of the animals. Through this system, children can enjoy this learning process and get a lot of detailed and vivid information of the animals or exhibitions easily.

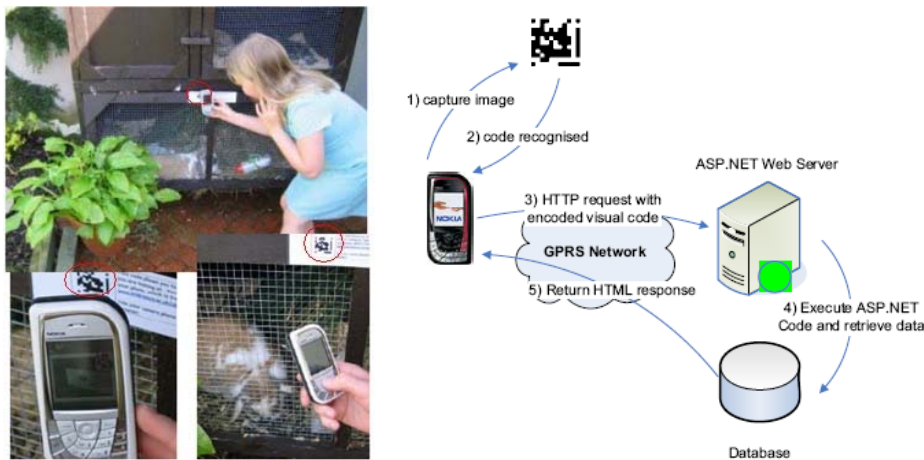


Figure 5. The interaction between a child and the uLearn visual code mobile application and the general system architecture [14]

System six: information of exhibitions can be gained using mobile phones and cameras. [1]

This system provided a prototype based on vision recognition. It tried to build a smarter environment to let the user easy to gain a detail of a painting in a museum. The users were equipped with a PDA, a webcam and headphones. The user point the web cam to a painting then the camera view will be displayed on the screen of the PDA in the user's hands. When the camera frames the painting, the detailed information and a short text label will be shown on the screen. Then the user can click the text label to retrieve some multimedia about the painting. This is the general system architecture in Figure 6. The key technology is the vision recognition engine which can recognize the paintings by the photo from the camera.

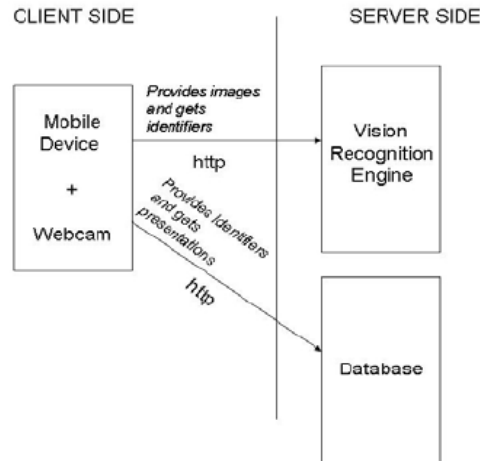


Figure 6. The general system architecture [1]

A comparison of these six systems is summarized as follows (Table 2):

Name	Mobile phone	PDA	Taking photos	Question And Answer
System 1		●		●
System 2	●		●	●
System 3		●		●
System 4		●		●
System 5	●		●	
System 6	●		●	

Table 2 a comparison of the six systems for mobile devices in museums

3. FIELD WORK STUDY

An ethnographic study was carried out at Universeum located in Gothenburg of Sweden, which is the biggest Science center in Scandinavia. Children can explore space, rainforest and the ocean. For example, in the Ocean Zone, there are diverse kinds of sharks, giant rays and moray eels. Children can get close to these animals in the Ocean Aquarium.

3.1 Ethnographic field work

Ethnography is defined as the science of cultural description by Wolcott [19, 20]. Ethnography is mainly a process which tries to describe and interpret social expressions between people and groups [3]. New ethnography is an effective research method, as Van Maanen mentions ethnography “involves extensive fieldwork of various types including participant observation, formal and informal interviewing, document collecting, filming, recording and so on.” [16]. The practical process of doing an ethnographic field work is firstly getting in to the environment, secondly becoming invisible and then watching, listening and learning at the same time making field notes. After the field work the field notes should be documented and analyzed [3]. In this master thesis study I did a short ethnographic field study before and after designing the prototype. Firstly I did ethnographic observations to find out social behaviors of children and their use of mobile phones and cameras in Universeum. Then using this data I designed a learning system for them. After the development of the mobile prototype (Fotofiske), I did another short ethnographic field work to evaluate the Fotofiske and try to get some feedbacks from children.

3.2 Practical approach for data collection

I got the permission from Universeum to do the field study there. The whole field study includes five workdays and two weekend days, around 39 hours at Universeum. There is a big ocean aquarium in the ocean zone where is a good place to do observation, as children would like to spend some time to see the fish and the sharks there.

I focused on observing children aged from 4 to 12 years old and their behaviors. Most of the times, I did some observations in front of the big ocean aquarium anonymously. Universeum is public place, so I took some photos of children who were talking or capturing photos of fish and most of these photos only can see the children's back. Sometimes some informal interviews were done with the parents of children. The informal interviews are some kind of chat with the parents. The questions are like "How old is the boy/ the girl?" and "Can he or she take some photos?" The observations, the photos of children and the information from the chatting with parents were documented in field notes. In the field notes, when there are several boys or girls within a case, these boys or girls are named "boy A", "boy B", "boy C", etc or "girl A", "girl B", "girl C", etc. Sometimes I asked the parents about the age of a child, and this kind of accurate number will be marked as "*", such as "*11 years old". Otherwise, it is an estimated age.

From the field study, I would like to address questions: "What are children interested in at Universeum?", "What do they usually do when visiting Universeum?" and "What do children do with their mobile phones while visiting Universeum?"

3.3 The data, findings and analysis

From the field study in Universeum, I find that during the workdays, most of children there are organized by schools and in the weekends children go there with their parents. The data from field notes are analyzed in this section. Cases are classified into themes. More cases for each theme could be found in Appendix A.

There are firstly some themes (from a to e) which mainly describe some common behaviors of children in Universeum. Some of the findings quite conform to the results of paper [2] described in the related work previously. For example, large scaled exhibitions are more attractive for children; children would like to spend more time to the exhibitions which full with more interaction. Then there are some themes (from f to i) related to the mobile phone use of children in Universeum. For example, I found lots of children prefer to use their mobile phone to take photos of fish in Universeum and share these pictures with others; some children also would like to view photos captured by others.

a. Children prefer to pay more time in the place where they could have more interaction with the facilities or the exhibitions.

In the exploration room of Universeum, there were usually more people than in the rainforest and in the ocean zone, as the exploration room has lots of facilities which children could manipulate or feel physically. This finding matched a finding in the paper [2] mentioned in the related work that the format of exhibitions have a great influence on children's learning process. Children would like to pay some time on facilities which are full of interaction possibilities. This finding conforms to the general idea of this master thesis project of using mobile phones to build an interaction between children and museums.

b. Children prefer to discuss with their classmates or parents about the animals in Universeum.

In these two cases below, when children were watching the exhibitions, they would like to talk with their classmates and discuss with each other. Maybe everyone knew something about the exhibition. Through the discussing they could learn from each other.

Case 1: Eight or nine children (most of them are boy) were watching the snakes on the other side of the glass which is on the bottom of the rainforest. (Figure 7 left) They were discussing with each other about the snakes. It lasted around five to six minutes, and then they went away.

After a while another two boys came. They discussed with each other and pointed to the snakes. They compared the two snakes in the rainforest.

Case 2: There are eighteen students from an English school. The teacher said the average age of these students is 12. Some of them maybe younger and some of them maybe older and all of them had mobile phones. The students

are divided into several groups and each group has three or four students. Two guides guided each group of students.

A group (group 1) of these children came in front of the ocean aquarium. There were three girls and two guides.

A (a girl): "That fish is from England."

B (another girl): "It is the tiger shark?"

Two guides guided them. The guides introduced fish and sharks. The students were focusing on watching and listening or asking questions, so no one took photos using their mobile phones.

Another group (group2) had three boys and two girls with two guides.

A (boy): "Look at that!"

B (boy): "Oh, cool."

Then a guide explained a lot of things about the fish.

B: "Is it Zebra there?"

A: "Look at that how long it is!"

B: "Oh, cute!"

A: "Oh that is so strange." (He meant the sawfish.)

A: "That is so fun" the boy used gestures to describe the fish.

A: "It is the tiger shark."

B: "Huge!"

A: "That is so funny."

The guide explained some habit of this Sand tiger Shark.

B: "Really?"

I can only hear two boys' voice who spoke quite loud.

After a while they went to other place.

From case 2, it seems that boys are usually more active than girls and ask more questions.



Figure 7. the children in case 1 and a group of children in case 2

c. Children would like to share interesting or amazing findings with their classmates or parents.

When a child found some interesting things (the snakes), he/she would like to share his/her findings with others, such as classmates or other family members. This gives good implications that we could provide them a platform to let them share their experiences with each other. In the case 1, the child prefers to ask his friends to go to the place where he has found some interesting or amazing things.

Case 1: A boy found the snakes on the bottom of the rainforest and then he asked two of his classmates to look. Three boys stood in front of the glass and they watched and talked about the snakes.

In the case 2, the boy would like to share his findings with his family members. He could not bring along or keep what he had found. Then he went away. If he can take a photo, maybe later he can describe his findings

using the photo to his mother or other friends, just as the images described before in the related work. In that paper, it mentioned people captured some photos to share experience with absent friends or family for the affective reasons [12].

Case 2: There were a boy A (around 6 to 7 years old) and a boy B (around 8 to 9 years old) in front of the ocean aquarium. Boy A found some interesting fish. Then boy A turned back and wanted to share his finding. However his parents were not there. Boy A seemed very sad. After a minute, he found his mother. Then boy A was very excited and said “come, mama, see here”. His mother and father came. He explained some fish to them. However his mother wanted to go to other place. While they were going, Boy A still explained, described and pointed something to B and his father.

In the case 3, when a girl found some interesting things, she shared it with her friend immediately. The girl's friend's reaction is to capture a picture of the finding probably for a kind of affective reasons described in the paper [12].

*Case 3: There were two girls A and B (*10 years old) in the archway of the ocean aquarium. They were both very excited and watched the fish. Girl A always talked and pointed some fish to girl B. Then Girl B took some photos of fish using her mobile phone. At a time, while a big shark was swimming across the archway, they were very happy and girl A was pointing and girl B was trying to capture a photo of that shark. After that, girl B showed some pictures to girl A in B's mobile phone. Then they were seeing fish for a while and then went away.*



Figure 8. The two girls in the case 3 sharing the photos

d. Children sometimes use gestures to describe the findings (a fish) for his/her friends or family.

From the cases below, it seems that what a fish looks like leave the first impression for children. When children learn a fish, they firstly get to know the scale, the shape and the color of the fish. This finding gives me a good implication that when designing the mobile prototype, it is better to introduce fish to children by describing fish name and what fish looks like. This design strategy conforms to the finding in the paper [2] mentioned in the related work section that it is better to introduce some knowledge to children in their familiar way.

Case 1: There was a boy (around 3 or 4 years old) with his mother in front of the ocean aquarium.

The boy: “the biggest one.”

The boy used some body gestures to describe and said “this big!”

“See!” he pointed to another bigger fish.

“That is the biggest shark! Mama”

“Look at this one mama.”

“I like that fish!” he pointed

He held his guide paper in his hands.

“I know that fish!” he pointed to one fish

At 11:23, they went away.

Because the boy spoke loudly, I could hear his voice only.

Case 2: There was a mother with a girl (around 4 to 5 years old) and a boy (8 to 9 years old) in front of the ocean aquarium. The boy used some hand gestures to describe the saw fish's nose to his mother and sometimes pointed to some sharks.

e. Children are more interested in big animals (such as sharks or big fish) and colorful fish.

Lots of children are interested in big sharks and sawfish in the ocean aquarium and the colorful fish exhibitions. This finding matches a finding in the paper [2] mentioned in the related work part that large scaled exhibition can be easily remembered by children. Thus when designing the mobile application, big sharks and fish and colorful fish are used in the prototype (Fotofiske).

Case 1: when a big shark came close, almost all of the children were looking at it. One of children also captured a photo of that big shark with his camera. (Figure 9 left)

Case 2: A number of children were in front of the ocean aquarium with their parents. (Figure 9 right) Some of them were around eight or nine years old. However most of them were two to five years old. One of the little boys (around 5 years old) spoke English and talked with his mother. He described some sharks and fish to his mother.

The boy said: "Look that big!"

The boy said: "Big fish has gone."

The boy also described something to himself sometimes.

The boy said: "Blue fish, wow."

The boy said: "That is the big one. Can you see?"

The boy said: "Look at this big one."

Another boy sat with his mother and was excited and watched the fish and sharks.

At 14:20, almost all of these people went away.

It seems that children would like to be in group. Even though they do not know each other, they could naturally play and talk with each other.



Figure 9. The children in case 1 and the children in case 2

Case 3: there are five children in front of colorful fish exhibition. A boy (around nine or ten years old) was using his mobile phone to take photos of the colorful fish. After a while, I found that everybody had mobile phones and took some photos of the fish. They also compared their photos with each other. They stayed around five minutes and then they went to the rainforest.



Figure 10. The children in front of the colorful fish exhibition in case 3

f. Children use their mobile phones or cameras to capture photos or record videos of interesting animals.

Children aged above 9 years old may have mobile phones and they take pictures using their mobile phones; some small children below 8 years old may not have mobile phones or cameras and they sometimes use their parents' mobile phone to take photos. It seems many children would like to take photos. This finding conforms to a finding mentioned in the paper [11] in the related work that the second frequently used function of mobile phones among children is to take pictures or to record sound and video. This finding gives me an idea that capturing photos could be a part of the mobile application.

From this case 1 we can also get the idea that children would also like to view the display of mobile phones to find out what his friend was capturing. The two boy also reviewed the photo together. This phenomenon is quite similar with the findings in the paper [18] that the teenagers sharing some text messages with each other.

***Case 1:** a group of children (around 10 to 11 years old) watched the fishes in the ocean aquarium. They wandered there for several times. Some of them took photos using mobile phones, especially when a big fish was coming. For example in the picture below, while the big saw fish was coming, almost all of the children were trying to capture a photo of it. I found most of them had mobile phones. After a while, a guide guided them to other place. (Figure 11)*

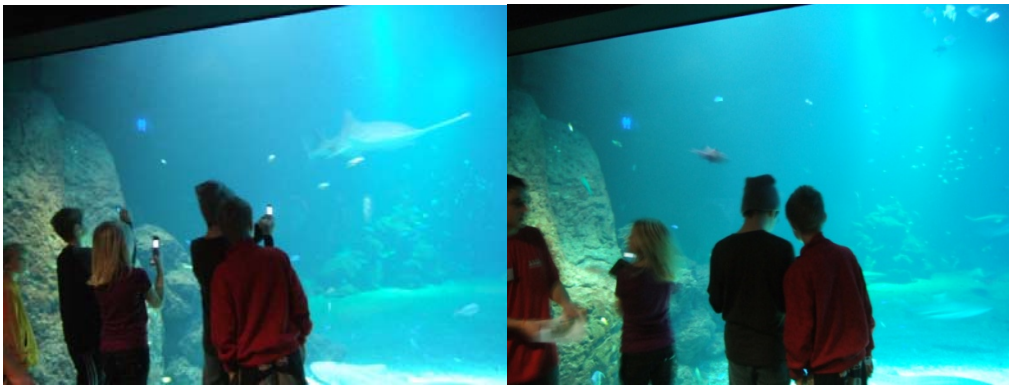


Figure 11. The children were taking photos of fish in front of the ocean aquarium in case 1

***Case 2:** There was a boy (around 13 to 14 years old), a girl (* 11 years old), two children (below 5 years old) and a mother in the archway of the ocean aquarium. The girl was very interested in the sawfish and chased with the sawfish. She captured a lot of photos of the sawfish using a mobile phone. Every time when she finished the capture, she put her mobile phone back to her mobile phone small bag. The saw fish went across the archway around twice or three times. Every time the girl was very exciting and was busy chasing and capturing the fish. At the last time, she captured a good photo and showed it to her mother with the mobile phone in her hand. The brother also pointed to some other fish and let the girl to capture a photo. (Figure 12 left)*

***Case 3:** There was a boy (*13 years old) and a girl (*12 years old) with their mother and father in the archway of the ocean aquarium. The children were very interested in big fish. They record some videos of fish using their mobile phones three or four times. (Figure 12 right)*



Figure 12. The children in case 2 and the children in case 3

g. Even quite small children have the ability to take photos (with or without the help from parents).

Some small children (below 6 years old) would like to use mobile phones to take photos of fish. In this situation, most of the children use their parents' mobile phones and sometimes need their parents help to manipulate the mobile phones. This finding gives me a good argument of my mobile application that small children could use my mobile application (Fotofiske) with the help from their parents.

Case1: There was a boy (five years old) and his mother. (Figure 13 left) The boy used his mother's mobile phone and took a photo of fish. Sometimes the boy met some problems, and then he turned back to his mother for help. His mother used that mobile phone took photos around three times. The boy took photos using that mobile phone twice. Every time after the boy finishing capture a photo, he gave the phone back to his mother and the mother usually checked the photos on the phone. I asked the mother and she said her boy could take photos using the mobile phone.*

*Case 2: There was a boy (*5 years old) with his mother in front of the ocean aquarium. (Figure 13 right) The boy took some photos of fish using a mobile phone. There were lots of people taking pictures at the same time. Sometimes he met some problems and then he went back to his mother for help. I asked his mother and she said it is her mobile phone, not the boy's.*



Figure 13. The boy and his mother in case 1 and the small boy using his mother mobile phone in case 2

h. Children would like to review and share the photos they captured with their classmates or other family members.

When children have captured some interesting things or good photos, they would like to share it with others. This situation is similar to one of the findings in the paper [18] that teenagers share their SMS-messages by showing their display of mobile phones. This finding also matches a finding in the paper [11] that children several times got together and shared videos, pictures or music with each other in the casual playground (mentioned in the related work).

In case 1, the girl was very interested in reviewing her photos captured before and shared these images with her father.



Figure 14. The girl shared her photos with her father in case 1.

***Case 1:** From 13:55 to 14:15, a girl (around 11 years old) took lots of photos of fish in front of the big ocean pool. After a while she went back to her father who was sitting on the bench. She talked with her father and showed her pictures to him. She showed and explained what she had captured. After a while, her father pointed to some fish. However the girl was quite interested in showing her photos to her father and explained. After that, she checked her pictures herself and then put the mobile phone back into her pocket. When a colorful fish was coming, she was very happy and let her father see. After a while, they went away. [Figure 14]*

In the case 2 the boy A took an interesting photo and he shared this image immediately with his friend to let them join the experience. This kind of images just matches a kind of images described in the paper [12] (mentioned in the related work). These images are captured for affective reasons and used to share some mutual experience with friends immediately face to face.

***Case 2:** There were four boys (around 11 to 12 years old) in the archway of the ocean aquarium. Every boy held a mobile phone. Boy A took a photo of a man diving in the ocean aquarium. The other three boys were watching fish in the aquarium. Boy A showed his photo of the diving man to boy B and boy C and they were very excited to see the photo and happy. Then boy B, boy C and boy D pointed and said “big shark”. Then they took some photos using their mobile phones. (Figure 15 left)*

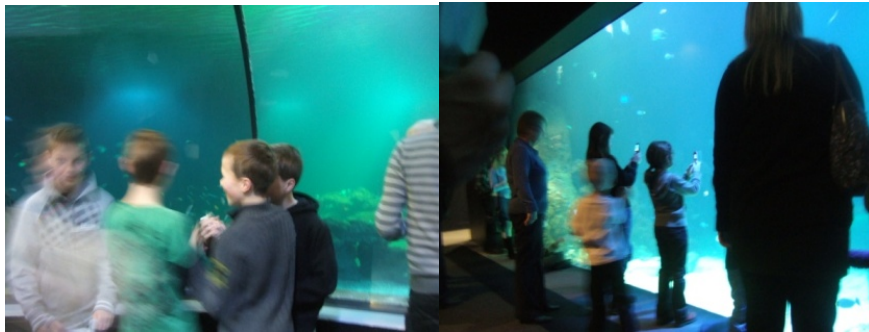


Figure 15. The boys in case 1 and the girl in case 2.

The small girl captured some interesting fish herself and she shared her photos with her grandmother and girl B. Using these photos she described some fish to them. This gives me a good argument for my mobile prototype (Fotofiske) that children could use the fish names, the fish description and the fish photos captured them own in the Fotofiske to help them to share what they have learned with their friends or families.

***Case 3:** There were a girl A (*9 years old) with her grandmother and a girl B (7 or 8 years old) with her grandmother in front of the ocean aquarium. It seems the two grandmothers were friends and were sitting on the bench. The girls were in front and watched the fish and sometimes they were back to their grandmothers. Girl A had a mobile phone and took several photos using it. She was very busy going to the archway and back several times to find some particular fish or sharks. She took some pictures of fishes. At a time she came back to her grandmother and showed a photo to her and pointed to the archway at the same time and explained something. It seemed she captured a good photo. At the same time girl B was trying to view girl A's picture to find out what girl A had taken. Girl A sometimes came back to her grandmother. However when she found some interesting fish across, she stood up and went to the front or went to the archway and tried to capture some photos. At a time, when the Zebra shark came across, she left the bench and went in front of the pool right away and tried to capture and then chased the fish to the archway and then back in front and watched and then back to the bench and sat with her grandmother. (Figure 15 right)*

i. Children are interested in viewing the photos captured by their classmates or other family members.

The last finding of this field study is that children are very interested in viewing the display of others' mobile phones to find out what others are capturing. It seems children are curious about what others are doing. From some observations I also find that children sometimes do not know each other before ,but they can share something with each other and played and talk with each other naturally.

***Case 1:** There were a boy A (*8 years old) and a boy B (*7 years old) and their grandfather in front of the ocean aquarium. B pointed a fish to A and then A took a photo of that fish. While A was taking the photo, B was trying to*

view the screen of A's mobile phone. B was trying to viewing the process of A taking photos through the A's mobile phone. (Figure 16 left)

Case 2: There was a boy (* 5 years old) with his mother in front of the ocean aquarium. A guide introduced and explained some fish. After that, the mother took some photos using her mobile phone. At a time, the boy wanted his mother's mobile phone. The mother was sitting on the bench in front of the aquarium. Then he (A) used this mobile phone to take two or three pictures. While he (A) was taking the photos, another smaller boy (B) was viewing his screen of mobile phone and seeing what boy (A) was taking. The boy B may be only 3 to 5 years old and they didn't know each other. After that the boy A turned the mobile phone back to his mother. The mother viewed what the boy A took and put the cell back to her pocket. I asked the mother and she said her son can use the mobile to take photos. (Figure 16 right)



Figure 16. The two boys in case 1 and the two boys in case 2.

3.4 Implications for design

Based on the findings presented above, there are some implications for designing a system for children's learning in Universeum.

Firstly, children would like to pay some time on facilities which they could have more interaction with. This finding conforms to the general idea of this master thesis project that we explore how to use mobile phones to build an interaction between children and museums.

Secondly, children often discuss with each other. Through the discussions they can learn from each other. When a child has found some interesting things (e.g. snakes or sharks), he/she would like to share his/her findings with others, such as classmates or other family members. Thus it is better to provide a platform to let children to discuss and share their common experiences in Universeum.

Thirdly, it seems that what a fish looks like leave the first impression for children. When children learn a fish, they firstly get to know the scale, the shape and the color of the fish. This finding gives me a good implication when designing the mobile prototype (Fotofiske). It is better to introduce fish to children by describing a fish name and what a fish looks like.

Lots of children are interested in the big sharks and sawfish in the ocean aquarium and the colorful fish exhibitions. Thus when designing the mobile application, big sharks and fish and some colorful fish are used in the prototype (Fotofiske).

It seems many children would like to take photos. This finding implicates capturing photos could be a part of the mobile application.

Some small children (below 6 years old) also would like to use mobile phones or cameras to take photos of fish. In this situation, most of the children use their parents' mobile phones and sometimes need their parents help to manipulate the mobile phones. This finding gives me a good argument of the mobile application (Fotofiske) that small children could use the mobile prototype (Fotofiske) with the help of their parents.

When children have captured some interesting things or good photos, they would like to share it with others. Using photos in their mobile phones, children can describe some interesting fish to their friends or family. This gives me a good argument for the mobile prototype (Fotofiske) that children could use the fish names,

the fish descriptions and the fish photos they captured in the Fotofiske to assist them to share what they have learned with their absent friends or families.

The last findings of this field study is that children are very interested in viewing the display of others' mobile phones to find out what others are capturing. It seems children are curious about what others are doing.

Thus a system is better to combine taking photo and fish and provides a platform for children to share with others.

4. APPLICATION DESIGN (FRAMWORK)

This part will describe a system design based on the literature review and the field study in Universeum at Gothenburg, Sweden.

4.1 System Design

From the literature review and the field study I found children can use mobile phones to do some play activities. For example children can use the photo function to create a game [11]; children would like to take photos when they have found some interesting things. In the field study I also found children would like to share their photos with their friends or family members. This aspect also matches some findings in the paper [12]. Some common behaviors of the children in museum are almost the same as the findings of others [2], such as children like big exhibitions. From reviewing some current mobile devices used in the museums, I found lots of learning systems are implemented in the question-answer form, like Musex and MyArtSpace. Some of them let the users take a photo of a particular "visual code" and the real frame of paintings and then the mobile device retrieve some information of the exhibition.

Based on the findings of the literature review and the field study a new system is designed for Universeum. This system has two parts. The first parts are applications running on mobile phones and the second part is a web portal. (Figure 17)

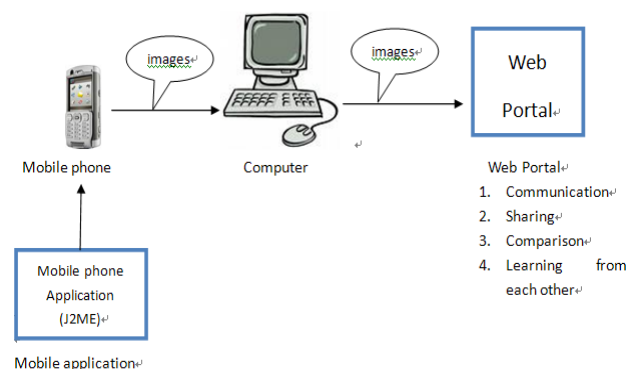


Figure 17. The general design of the system.

The mobile applications are question-answer based applications. There are two levels of questions which are low level and high level. The low level includes five big fish or sharks' names and descriptions. The high level contains eight colorful fish's names and descriptions. The description of a fish or a shark describes what the fish or the shark looks like. Each fish or shark is a question. All of the fish and the sharks described in the application can be found in the Ocean Zone of Universeum. Using this application, children can select a fish by fish name and then read the fish description. Then there is a "camera" button. Children find a correct fish or shark which matches the description and then capture a photo of that fish as the correct answer to this question. (Figure 18)

During playing Fotofiske's process, children can learn some fish and sharks by reading the names and the descriptions of them. They can also easily answer the questions by taking photos of fish or sharks. The main focus is not capture very perfect photos. The primary aim is that children could learn fish and have pictures of fish taken by their own.

The web portal is somehow like a forum. Children can upload their pictures of fish or sharks to the web portal and add comments or leave messages for each other's pictures. It is platform for children to share their images with others. Through this way, children can also communicate with others who also have the similar pictures and discuss fish here. Children can compare their photos with each other and learn more knowledge from each other.

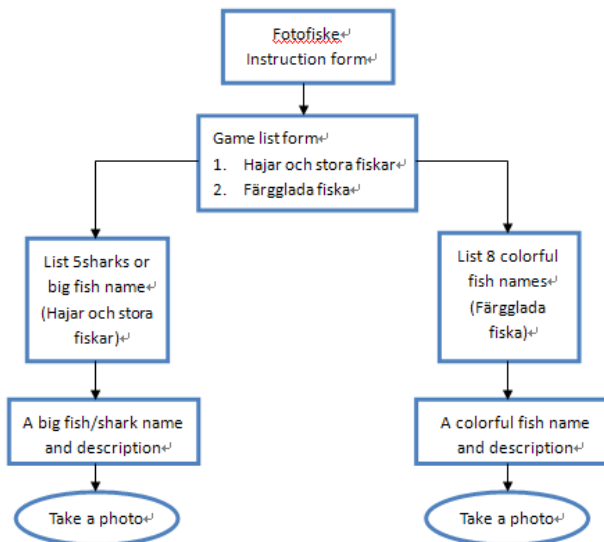


Figure 18. The design of the mobile application.

4.2 Mobile Application Requirements

This master thesis project is mainly focusing on detail designing and implementing the mobile applications of the system described before. The name of the mobile prototype is Fotofiske.

Functional requirements:

1. There is an instruction of Fotofiske firstly.
2. There are two levels of fish and sharks which is “a big fish and sharks” and “colorful fish”.
3. For each level of Fotofiske the fish or sharks’ names are listed.
4. For the unfinished questions, the icons of the fish names are a small red fish. For the finished questions, the icons of the fish names are a small green fish.
5. When selected one of the fish or sharks in the lists, a fish or a shark description is shown. At the same time a camera button appears.
6. Children can use the camera button to view the real place and a capture button is shown at the same time.
7. Children can capture a photo by click on the “capture” button.
8. Images can be saved on the local memory card of the mobile phone.
9. Users could review the questions and the images they captured.
10. If a user is not satisfied the image he/she captured, he/she can capture again. The new one will replace the old picture.
11. Another correct answer application should be developed for both of the levels of the game. It should include a correct and clear picture for each shark or fish.

Non functional requirements:

1. The application should be easy to be used, to be manipulated and to be understood, as the target users are children.
2. The file size of the application should be the smaller the better.
3. The application should have some compatible abilities that it can run on different brands of mobile phones.

4.3 Questions Design

The field study reveals that children are interested in big fish or sharks and colorful fish, so I did some studies about these fish and sharks. I got a fish list which includes all of the fish in the Ocean Zone from the help of staff at Universeum. Then I used Google to find some pictures of these fish. According to the pictures I selected the most colorful ones and created the two fish lists firstly. My supervisor helped me to translate them from English to Swedish and help me to make the description better. Mikael Olsson and Klas Malmberg from Universeum helped me to correct the fish lists and gave suggestions to improve it. Then I went back to Universeum and selected fish which could be easily found. At last the two fish lists are shown as below.

For the low level of Fotofiske game there are five questions which are about big fish or sharks. Their names and descriptions are described in the Table 3.

No.	Fish Name	Description
1	Largetooth sawfish	A big and long nose looks like a saw.
2	Sand tiger shark	The biggest one in the ocean aquarium.
3	Zebra shark	Long tail and usually sitting on the seafloor. Cheetah patterned, despite of the name.
4	Nurse shark)	Hiding under submerged ledges or in crevices
5	Blacktip reef shark	A black tip of the tail; small shark

Table 3 The low level fish list in Fotofiske

For the high level of Fotofiske game there are eight questions which are about colorful fish. Their names and descriptions are described in the Table 4.

No.	Fish Name	Description
1	Yellowtail clownfish	Black, white and yellow stripes; yellow tail
2	Foxface	Fox face and yellow body and tail with a black spot on its body
3	Bird wrasse	Small mouth and blue green body
4	Copperband butterflyfish	White body, yellow bandings and long mouth
5	Lookdown fish	Silver color and swimming in groups
6	Palette surgeonfish	A royal blue body, yellow tail, and black 'palette' design
7	Royal gramma	Purple body and yellow tail
8	Whitetail dascyllus	White body with three black vertical bars

Table 4 The high level fish list in Fotofiske

5. PROTOTYPE IMPLEMENTATION

In this master thesis project, a prototype of the mobile application is built which is called Fotofiske. The prototype is implemented in Swedish, as the target users are children who go to Universeum in Gothenburg, Sweden.

The programming language is JAVA. The developing tool is NetBeans IDE 6.5. To use the camera function of mobile phones, Mobile Media API (MMAPI) 1.1 (JSR 135) is used in developing the application. To save images to the local file system of mobile phones, File Connection Optional Package (FCOP) is used in developing the application.

Some images of the application (Fotofiske) are shown in Figure 19 and Figure 20.



Figure 19. The instruction screen, the two levels of the game and the low level fish list



Figure 20. The high level fish list, a question which is not answered and a question which is answered.

The mobile phone application was tested on some real mobile phones. As the additional packages (MMAPI and FCOP) used in the application, it cannot run on all of mobile phones. However the application can now run successfully on some Sony Ericsson and Nokia mobile phones, such as Sony Ericsson W910i, Nokia 6120 and Nokia N73 Music Edition.

The answer application for Fotofiske is developed, as shown in Figure 21. There are two levels answers for the two level questions. There is a correct image for each fish.



Figure 21. The answer application for Fotofiske.

6. AN EVALUATION OF THE PROTOTYPE

My supervisor and I firstly had a meeting with two staff of Universeum and described previous field work there. We also introduced the prototype (Fotofiske) which was developed based on the previous work. They are very interested in Fotofiske, because it supports the behaviors of many young Universeum visitors. The application can run successful on one of the staff's mobile phone (Nokia).

6.1 Evaluation Approach

A first small evaluation was done by the helping of my supervisor and her family. Her son (5 years old) used this Fotofiske and finished five low level questions and two high level questions at Universeum.

A furthermore evaluation was carried on during one public holiday and two days of a weekend. I showed and introduced Fotofiske to a visitor and inquired if he/she or his/her children wanted to join in. When a user was using this Fotofiske game, I did some observations of the process. Twenty users used this application at different levels and helped me to finish the questionnaire about Fotofiske. In these twenty users, there are seventeen children (4 to 13 years old) and three teenagers or adults. During this evaluation, all of the users used my mobile phone, as this application cannot run on so many mobile phones and the users usually did not have enough time to wait for the transferring the application to their mobile phones. All of the children also helped me finish a questionnaire (Appendix B) with or without their parents' or others help. Some of cases in the evaluation are shown in the Appendix C.

6.2 Findings from the Evaluation

From the observations and the questionnaires, there are some findings to improve the mobile prototype:

a. Children think that Fotofiske game is interesting.

From the questionnaire, there are 14 users think Fotofiske is interesting and 6 of them think the game is very interesting.

In the case 1 the boy enjoyed this game and finished all of the questions.

Case 1: there was a 10 years old boy with his grandfather in front of the ocean aquarium. The grandfather was sitting on a bench. I introduced the Fotofiske game to his grandfather. Through this game I knew the boy could read Swedish and understand English. At first I showed how to manipulate the game. Then the boy could know how to manipulate the Fotofiske quickly and manage the mobile phone himself. Previous I saw he manipulated his own mobile and captured photos. He was enjoyed playing the Fotofiske game. When he finished a question and captured a clear photo of fish, he was very excited. He manipulated the mobile phone well. While a correct fish was swimming close, he did not capture it. He felt very pity for missing to capture it. The boy had enough patience to wait for the fish to swim to nearby and tried to find a good place to capture a picture in the archway and in front of the aquarium window. When he was not satisfied with the picture, he tried again to capture a good one. When the fish he knew, he could find the right one quickly. When he was not familiar with the fish and was trying to find the right one, he usually repeated the description of the fish. He also finished the questionnaire himself. After the boy finished all of the answered, he did not ask me for the correct answer. However I showed him the correct answer and he is interested in the colorful pictures. After all of the game, his grandfather stood up and wanted to leave, as it took so long time. (More than 20 minutes)

He finished 4 low level questions and 7 high level questions. He learned 8 fish. He thought the Fotofisk is very interesting and not difficult to use.

b. Small children (below 7 years old) need their parents or elder brother/sister's help to manipulate Fotofiske.

Case 1: there were a boy (4 years old) and a girl (6 years old) with their mother and father.

The mother helped them to use the mobile phone and read the description for the children. The children tried to find. The mother found the right one and pointed it for the children. While the mother used the phone to capture the right shark, two children got close and viewed the screen of the mobile phone. They finished 3 questions and learned 3 sharks. The children think the game is interesting but it is difficult to use.

c. When a child is playing the Fotofiske game, other children (the child's friends, brother or sister) often help the child to find the correct fish.

Case 1: There was a 7 years old boy with his father, mother and an older sister. All of them speak English. I firstly asked the mother if the girl would like to play the fish game. However the girl said "No" and wanted to hide behind her mother. The mother said the girl was shy. At that time the boy said he wanted. Then I explained and showed him how to use it. The boy was little and did not have mobile phone. When the boy was using the mobile phone and tried to find the shark I translate the description for him. The girl said that "it is there" and helped his brother to find the correct shark and pointed it for the boy. The boy was not good at using the mobile phone to capture a picture. The boy could not read words, so the father helped him to read the questions for him and helped him to write down. I translated the question for the father. The boy answered 2 questions and learned 2 fish. The boy thought the game is interesting, but it is difficult to manipulate.

Case 2: There were two boys A and B (13 years old) from Norway. I saw them using their mobile phone to take photos of fish. They also were drinking ice fruit drinking. I tried to talk with boy A. However it seemed boy A was afraid of stranger talking to him. Then I tried to talk to boy B and showed the application to him. I encouraged him to use it. They did not know Swedish, so I read the description for them. He captured a good picture of Sand tiger shark. When he was doing the sawfish question, boy A found the fish firstly and pointed it to B. Then B took a photo of the fish and the photo is clear and good. Both boy A and boy B were very happy for this photo. Then we continued to find the small shark. Boy A and boy B found it at the same time. Boy B could find a good place and use the mobile phone to capture a good picture. We could not do the other sharks as there was a presentation in front of the ocean aquarium. The Zebra shark was just sitting there.

I read the questionnaire for them and wrote down their answer. They were drinking their fruit ice. The boy B finished 3 questions and learned 3 sharks. Both of them thought the game is interesting. Boy B thought it is not difficult to manipulate the game.

d. Children could learn some fish through playing this game.

Case 1: there was a 12 years old boy with his father in front of the ocean aquarium. I introduced the Fotofiske game to the boy and the father at the same time. They were sitting on bench. The boy could learn the game very quickly. At first the boy was a little bit shy and did not go to the front to capture. The boy could use the description to find the correct big fish, especially for the Zevrahaj and the small shark (he quickly found them). They had no time to continue. The boy filled the questionnaire himself. I explained the third question for him and then he recalled name but he cannot spell it. I listed the shark name again. Then he recalled and wrote the new learned sharks. The boy finished 4 questions and learned two fish. He thought the game is interesting and not difficult to use.

There is not so much time to let the children review the pictures they took, if they could use their own mobile phones and review the questions and the pictures they captured, they could learn more and remember more fish.

Case 2: there was a boy (12 years old) with his elder brother in front of the ocean aquarium. The boy could communicate with me. I asked him how many shark he learned from this game. He said he did not know the sharks exactly before. Through this game, he learned them. The boy could read the description and found the correct one quickly. He can use the mobile phone himself. He filled in the questionnaire himself. I saw both of them had mobile phones and used them to capture pictures. The boy finished 4 questions and learned 4 fish. He thought the game was very interesting and difficult to use.

e. Users often mention that taking a good picture of fish (as an answer) is difficult.

Children have to stay in front of the ocean aquarium for a long time to wait for the correct fish to swim close. While the correct fish is close, they have to quickly capture a photo of the fish. Some small children are not good at manipulating mobile phones.

Case 1: there was a boy (11 years old) with his elder brother in front of the ocean aquarium. When I first talked to them, the younger boy seemed be afraid of strangers. They were using their mobile phones to take pictures. Then I introduced Fotofiske to them. The younger boy used Fotofiske. His brother helped him to find some fish, like Zebra shark. The boy could use the mobile phone very well, but sometimes to capture a good picture is difficult. He went around finding a good place to capture a good picture of the correct shark. For example he captured the Zebra shark for several times, as the shark was swimming a little bit quickly at that time. He said he did not know all of the sharks before. When he was playing the game, the Nurse shark which was usually hide in dark place was sitting on the bottom. This situation might be confusing to the boy between the Zebra shark and Nurse Shark. He firstly thought it is the Zebra shark. However after a few seconds, he said it is not, as it did not have black spots. He finished 5 low level questions and learned 5 fish. He thought the game is interesting and difficult to use.

It is better to find a way to help children to captured a good picture easily or switch among questions easily

f. Families usually have their own schedule of the visit, so they do not have enough time to participate in the Fotofiske game.

Lots of people rejected to participate in the Fotofiske game, as they did not have so much time to do it. Some people were in a group. Not all of the people wanted to participate in it and the one who wanted to play did not want to lose her/his group. In the other situation, a big family came to Universeum (usually more than five people), other people did not want to wait for the children to do it for a long time. Some families had their schedule, so they do not have enough time to play it. For example, one of children's mothers showed me her time schedule which is a time table of programs in a news paper.

Case 1: there was a boy 12 years old with his mother, father and two younger sisters in the ocean zone. The boy could use the phone himself very well. I would like to suggest them to do the colorful fish level. The mother said they have to go. The boy did four questions and learned the sandtigerhaj and Zebrahaj. He thought that Fotofiske is interesting and not difficult to use.

To overcome this problem, it is better to publish Fotofiske on the web site of Universeum to let people to freely download. It is necessary to clearly state that the Fotofiske is free of charge. In this way, firstly parents can know this game before visiting Universeum and fit the playing of the game in their schedule. Secondly they can download Fotofiske at home and install it on their mobile phones. It can help them to save time when they are visiting. Thirdly, children can learn how to use Fotofiske before visiting Universeum. At last, the fish names and descriptions in Fotofiske may promote people to visit Universeum.

g. There should be multiple language versions of Fotofiske.

The prototype (Fotofiske) is implemented in Swedish. In this evaluation, there are three users from other countries and some of them do not know Swedish. One adult from China do not know Swedish. One family is from Norway and the parents know Swedish, but the children do not know Swedish. Two boys are from Norway and do not know Swedish. While they were using Fotofiske, children need others help to translate the descriptions of fish for them.

Case 1: there was a boy (10.5 years old) with his mother, father and younger brother. They were from Norway. The mother helped the boy to read the description of the fish, as the boy do not familiar with Swedish. When the boy tried to find the Sand tiger shark, his younger brother firstly found it and pointed it for the boy. The children could use the description found the correct one. He could use the mobile phone very well. He finished 4 low level questions and 5 high level questions and learned 4 sharks. He could not remember the exact fish name of the

colorful fish. He thought the game is interesting and not difficult to use. He gave some suggestions: "more choice language" and "easier to see the photos in the camera".

h. Teenagers/adults care more about getting the correct answers when they finished than children.

Case 1: there was a 15 years old girl with his friends (three or four). When I introduced the game to her, she said "interesting" several times. She was very happy to play Fotofiske and could manipulate it very well. She tried to find the fish quickly and chasing with the correct fish fast. However she had no time to continue, as she had to find her friends. (The group already gone away)

She answered 4 low level questions and learned 3 new fish. She thought the game is very interesting and not difficult to manipulate. She gave me some suggestions "more description about sharks and fish" and "She wants to know if the fish she captured is right or wrong quickly just after she captured the images."

Children think differently about the relevance of correct answers from teenagers or adults. The teenager in the case wants to check the right answers. In another case, when the mother helped her young son to fill in the questionnaire, she suggested to her son if he wanted to know the correct answers after his finishing of the questions. However her son said "No". It seems children do not care much about if they are right or wrong. In the small evaluation no children asked me to provide the correct answer.

7. DISCUSSION

The aim of the master thesis project is to explore how to use mobile phones to assist children's learning in an interesting way in Universeum.

The study started with a literature review focusing on the relationship among children, mobile phones and museums. From reviewing the current mobile devices used in museums, I found that most of the learning systems are question-answer form. Some of digital guide systems use the camera functions of mobile phones. The mobile prototype (Fotofiske) adopts relevant aspects of these systems and creates a new form of question-answer system, which allows users to answer to questions by capturing photos. As the general design of the prototype is using the camera function of mobile phones, I did another literature review about the use of camera mobile phones.

During the second phase of the master thesis project I did a short ethnographic field study in Universeum. Firstly some findings of common behaviors of children in my field study conform to some findings in the papers [2, 11, 18] mentioned in the related work. For example, children would like to pay more time on facilities which they can interact with. This supports the general idea of this master thesis project, which aims to find a way to use mobile phones to build an interaction between children and museums. It is found that children are interested in big fish or sharks which are mentioned in the paper [2] that children are interested in large-scale exhibitions. This finding gave me the idea of using sharks and big fish in my mobile application. When children captured some interesting things or good photos, they would like to share it with others. This situation is quite similar to one of findings in the paper [18] that teenagers shared their SMS-messages by showing their display of mobile phones. In the paper [11], children got together and shared videos, pictures or music with each other.

The field study reveals that children would like discuss with each other. By discussing, they can learn from each other. Children also prefer to share his/her interesting findings with others, such as classmates or other family members. This gave me the idea to provide a platform to let children to discuss and share their common experiences in Universeum.

From the field study, I found children used some body gestures to describe fish or sharks. It seems that what a fish looks like leave the first impression for children. This gives me a good implication when designing the mobile prototype (Fotofiske) that it is better to introduce some fish to children by describing a fish name and what a fish looks like. This design strategy conforms to the finding in the paper [2] mentioned in the related work section that it is better to introduce some knowledge to children in a familiar way to them.

I found children would like to take photos. This finding conforms to a finding mentioned in the paper [11] in the related work section that the second frequently used function of mobile phones among children is to

take pictures or to record sound and video. This finding implicates that capturing photos could be a part of the mobile application.

Some small children (below 6 years old) also would like to use mobile phones to take photos of fish. In this situation, most of the children used their parents' mobile phones and sometimes needed their parents' help to manipulate the mobile phones. This finding gives me a good argument of my mobile application that small children could use the mobile application (Fotofiske) with the help of their parents.

When children took an interesting photo, they wanted to share this image immediately with a friend to let them take part of this enjoyable moment. This kind of images matches a kind of images described in the paper [12] mentioned in the related work. These images are captured for affective reasons and used to share some mutual experience with friends immediately face to face.

Some children captured something interesting and then they would like to share their photos with others who did not see the same thing. This gives me a good argument for my mobile prototype (Fotofiske) that children could use the fish names, the fish descriptions and the fish photos captured them own in Fotofiske to assist them to share what they have learned with their absent friends or families.

The last findings from the field is that children are very interested in viewing the display of others' mobile phones to find out what others are capturing.

Based on these results from the field study, as well as the results from the literature review, a system which includes a web portal and a mobile application is designed. The web portal is a platform for children to discuss, to communicate, to share and to learn from each other. The mobile phone application is a tool which helps children to learn fish in an interesting way when visiting Universeum. A prototype of the mobile application named Fotofiske is developed. Fotofiske provides some information of fish to children. Children find and capture photos of a fish which matches the description in Fotofiske.

In the last part of the thesis project, a short evaluation of the prototype was carried out to get some feedback from children and then to get some ideas about how to improve Fotofiske. From the evaluation, there are some useful findings. Firstly, this prototype is successful in that all children who used it thought that Fotofiske is interesting or even very interesting. Secondly, children were able to learn some fish using Fotofiske. Thirdly while a child was playing Fotofiske, other children often helped the child to find the correct fish. It shows that Fotofiske could be played in groups to make more fun. Fourthly, there is a difference when comparing children to teenagers or adults thought about the relevance of correct answers. Teenagers and adults want to check the right answer. However it seems children do not care much about if they are right or wrong. In the small evaluation no children asked me to provide the correct answer. However some problems also became evident in the field evaluation. Firstly families often have a schedule of their own, so it is better to publish Fotofiske on the web site of Universeum to let people freely download it before going to the museum. Then they can make playing Fotofiske in their schedule of the visit. Secondly when I introduced Fotofiske to a father, he asked me if he needed to pay for it, so it is necessary to clearly state that the Fotofiske is free of charge. Thirdly some visitors were from other countries such as (China and Norway), so there should be multiple language versions of Fotofiske. At last it is better to find a way to help children to capture a good picture easily or switch among questions easily. These findings are very valuable when improving this mobile prototype (Fotofiske), and if it should be implemented large-scale at Universeum.

8. CONCLUSION

This master thesis presents an entire lifecycle study which includes field study, design and implementation, and evaluation. In the initial field study phase there are findings about children's common behaviors and how do they use their mobile phones in Universeum. According to the data from the field work and literature review of others' paper, a system which includes a mobile phone application and a web portal was designed. The mobile phone application is aimed to build the interaction between children and Univereum. The web portal provides a platform for children to communicate, to discuss, to learn or to share with each other. A prototype of the mobile phone application is developed and named Fotofiske. From a

short evaluation of the prototype (Fotofiske), there are some finding about how to improve it and how to deploy it.

From this study, Universeum is good place to gain knowledge for children. Mobile phones can be a good medium among children and Universeum. Using Fotofiske children can gain some knowledge about fish and sharks while they are playing. The mobile prototype (Fotofiske) can build the interaction among children and Universeum and bring children some fun.

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APPENDIX A

There are additional good cases in the initial field study which are organized by their categories:

- a. **Children prefer to pay more time on the place where they could have more interaction with the facilities or exhibitions.**
- b. **Children prefer to discuss with their classmates or parents about the animals in Universeum.**

Case 1: A group of children (around twenty children), eight years old, was watching the fish and sharks in front of the ocean aquarium. One of the boys held a camera and took some photos. A little girl took a photo using her mobile phone. The children sometimes discussed with each other. I asked one of their teachers and she said some of the children captured photos using mobile phones and cameras.



Figure 1. The children in case 1.

Case 2: A boy (around four or five years old) came with his sister and his mother in front of the ocean aquarium. They were watching fish and talked with each other. The boy explained something himself and sometimes shared his findings with his mother. At 11:55 they went away to the snake exhibition's room.

Case 3: There were students from an English school. They were divided into groups. A group of students had three boys (*11 years old, classmates) and two guides.

A (a boy): "Zebra are here!"

Guider1: "this is the black tail shark."

A: "Yes, that is sea name"

Guider1: "You know everything!"

Then they discussed about the sawfish.

A: "She comes"

A: "Oh they are 'rise fish'. They are in the sand."

Guider1: "the sand tiger shark comes"

A: "oh, big!"

The three boys are very smart. They knew a lot of names of fish. They also explained lots of knowledge about the fish or the sharks' habit to themselves and the guides. Then the guides were very surprising and said "Oh, you can guide us!" At 13:16, they went away.

The boy described some movements of a fish by body gestures.

At 13:22, there was another group of students including four girls (*11 years old).

A (a girl): "Look at that fish."

Then the girl took some photos using her mobile phone. At that time, the biggest shark in the ocean aquarium was coming.

A: "Oh, big!"

B (another girl) took a photo of that big shark.

C: "Look at that fish"

At 13:25 they went away to other place.

From this case, boys are usually more active than girls and usually asked more questions.

c. Children would like to share the interesting or amazing findings with their classmates or parents.

Case 1: Two boys (around seven to eight years old) found a big shark in the ocean aquarium and clicked hands with each other and then they went away. After a while, they brought other two boys here and pointed to the big shark for them and said something.



Figure 2. The children in case 1.

Case 2: There were three boys (*11 years old) and a teacher in front of the colorful fish exhibition. One of the boys held a mobile phone.

A (a boy): "This is tomato fish. It is different. "

A: "Oh, what is that green one?"

The teacher explained about the fish.

A: "Oh! Maybe"

A: "Oh, look at that ball."

A: "Oh, look at that"

B (the teacher): "That is sweet."

C (a boy): "Sharp fish"

A: "Look at that one. Something likes a pump"

B: "It is sunfish"

D held a mobile phone. However these three boys were enjoy in looking and discussing about the fishes and not taking photo. I could not hear two boys' voice clearly. When they went away, I asked the age of the boys and the using mobile phones. The teacher told me the students' age and said that all of them have mobile phones. Then they went to the rain forest.



Figure 3. The children in case 2.

- d. Children sometimes use gestures to describe his findings (a fish) for his/her friends or family members.
- e. Children are more interested in big animals (such as sharks or big fish) and colorful fish.

Case 1: two children (around 5 to 6 years old) were watching the fish and sharks in the ocean aquarium. While a big fish was coming close, the boy was excited and the girl pointed the fish.(left)

Case 2: There were two parents and three children. They sat in front of the ocean aquarium. While a big shark was coming close, they were all very happy. At 12:02 they went away.(right)

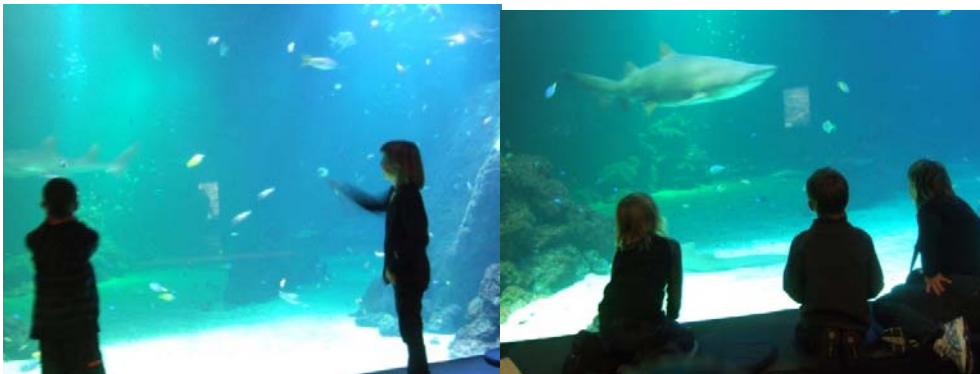


Figure 4. The children in case 2.

Case 3: Three girls and two boys (*eleven years old) were in the ocean zone. Three of them held mobile phones and another boy held a camera. At 13:33 they went around and took photos of sharks in the ocean aquarium. Then they went to the colorful fish exhibition and took some photos of the colorful fish. They told me they are eleven years old.



Figure 5. The children in case 3.

f. Children use their mobile phones or camera to capture some photos or record some videos of the interesting animals.

Case 1: A boy talked with his mother about the blackfish and the fish in the ocean aquarium. Then they went to the archway of the ocean aquarium. After a while, the boy came back and hold a camera. He took some photos of fish and then sat down on the bench in front of the ocean aquarium and viewed his photos. After a while he went to the archway again and photo something. He is very interested in one particular big shark. After a while he and his mother sat on the bench in front of the ocean aquarium. The boy held his camera and talked with his mother. He sometimes pointed to the introduction screen which include some description about the fish. When a big shark came close, he got up and watched. He watched the fish and sharks in the ocean aquarium and sometimes discussed something with his mother. At 16:30, he got up and went to the archway with his camera. Two minutes later, he came back and watched the pool and pointed to the introduction screen again. At the same time, he talked with his mother and made some gestures to describe something. At 16:35, he went to the snake exhibition room. At 16:58, I came across them at the bottom floor of Universeum, they watched the snakes and the boy took some photos of the snakes.



Figure 6. The children in case 1.

Case 2: There were two boys and two girls (around 10 to 11 years old) in front of the ocean aquarium. Two of them had mobile phones. "See!" one girl said and then she took a photo using her mobile phone. One of the boys pointed to a small fish for the other two children and then took a photo of that small fish.



Figure 7. The children in case 2.

Case 3: There was a small boy (* 7 years old) with his brother (*13 years old) and his father in front of the ocean aquarium. The small boy sometimes took photos using his mobile phone. He did not use the mobile phone so frequently as his elder brother. His brother held his mobile phone all the time, but the small boy usually put the mobile phone back to his pocket after using it.

From this case, it seems not all of children would like to capture so many photos using mobile phones.

Case 4: *There were a boy A (* 10 years old) and a boy B (7 years old) in front of the ocean aquarium. Boy A held a mobile phone in his hands. B asked A to watch the big pool and pointed to a fish. Then A used his mobile phone to take a photo. Then they still watched the fishes. After a while they went back to their parents sitting at another bench in the room.*

This case shows that taking photo is sometimes the natural reaction of a child when his/her friend pointed to some interesting things.

Case 5: *There was a boy (*10 years old) with his father in front of the ocean aquarium. I saw the boy several times. Sometimes the boy carried a mobile phone in his hands and sometimes he carried a camera. He took lots of photos of fish. His father said that the boy was very interested in animals. The boy very took photos quietly not talking to others and paid his attention on fish.*



Figure 8. The boy in case 5.

Case 6: *There were a girl A (*9 years old) and a girl B (*10 years old) with their mother and father in the ocean zone. Both of the girls had mobile phones and used them to record some videos and captured some photos of the colorful fish and some other exhibitions. At a time girl A showed girl B something in her mobile phone and they discussed something.*



Figure 9. The girls were recording videos in case 6.

- g. Even quite small children have the ability to take photos (with or without the help from parents).**

Case 1: *There was a boy (*4 years old) with his mother and father in the ocean zone. The boy took lots of photos of snakes and fish using a camera. He captured almost everything he saw. The mother said that it is the boy's new hobby to take photos and almost four tenth of the photos are good ones.*



Figure 10. The small boy was capturing photo in case 1.

- h. Children would like to review and share the photos they captured with their classmates or other family members.

Case 1: There were *seven girls (*11 years old) and they were classmates. Some of them took photos of fish and sharks using mobile phones.

A(a girl): “Is it ‘miko’? Cool! ” then she took some photos using her mobile phone.

B(another girl): “Oh my god! That is an amazing fish!”

C(the third girl): “Oh, look that” then she took a picture of that.

C explained the picture in her mobile phone and showed the picture to D (her classmate). C held the mobile phone and C and D viewed the photos together. C explained: “that is terrible!”

B: “That one goes to the inside!”

After a while they went to away to watch colorful fish.

When they finished watching fish, I asked them how many of them using mobile phones. They said all of them have mobile phones.



Figure 11. The girls were capturing photos in case 1.

Case 2: There were a girl A (*13 years old), a girl B (*9 years old) and their mother in front of the ocean aquarium. The girl B sat on the floor just close the glass of the ocean aquarium and took some photos using her mobile phone. Then she showed the photos to girl A and their mother. Then girl B passed her mobile phone to girl A. Girl A got the mobile phone and took some pictures using it. Then girl B passed the mobile phone back to girl B. Girl B viewed the photos which girl A took and then captured another some photos. Then their mother guided them away.

The mother said both of them have mobile phones.

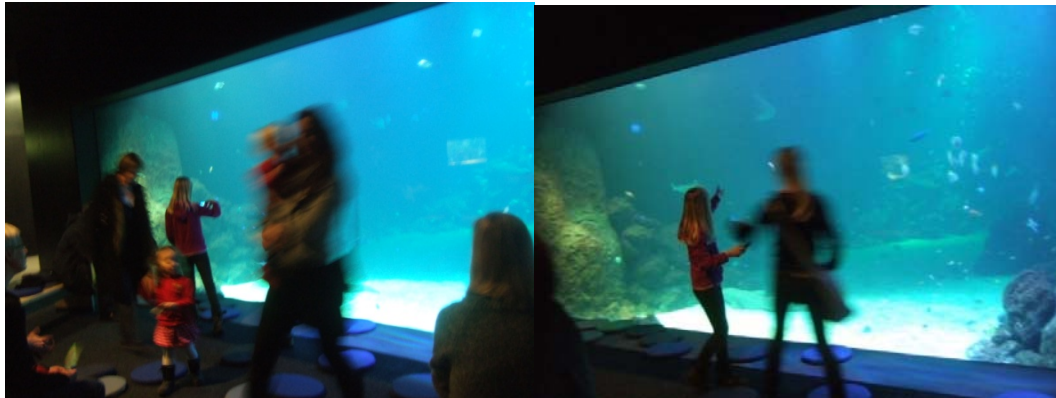


Figure 12. The two girls were capturing photos in case 2.

Case 3: There were a girl A (* 9 years old), a girl B (* 11 years old) and their mother in front of the ocean aquarium. Girl A carried a camera. She tried to take some photos of a fish and she sometimes shared her photos with her mother (girl A held the mobile phone). It seems that she was not satisfied with the photos which she captured. Then her mother took the camera and captured some photos and then they viewed the photos together. Then girl B came back to girl A and the mother and viewed the photos in the camera. Then she took the camera and started to take some photos. While a big shark was coming, Girl A was exciting and pointed it and let girl B take a photo. Then all of them checked the photo and then the camera turned back to their mother's hands. Their mother tried to find some good place where the light was good to capture a photo. She viewed through the camera to see the ocean aquarium and tried to find a good direction. After her finding a good place, she gave the camera back to the girl A. Then girl A took some pictures at that place and then shared the photos with her mother. The camera was held in girl A's hands.

Then they went to the archway and back around twice or three times to capture photos. After a while they went away.

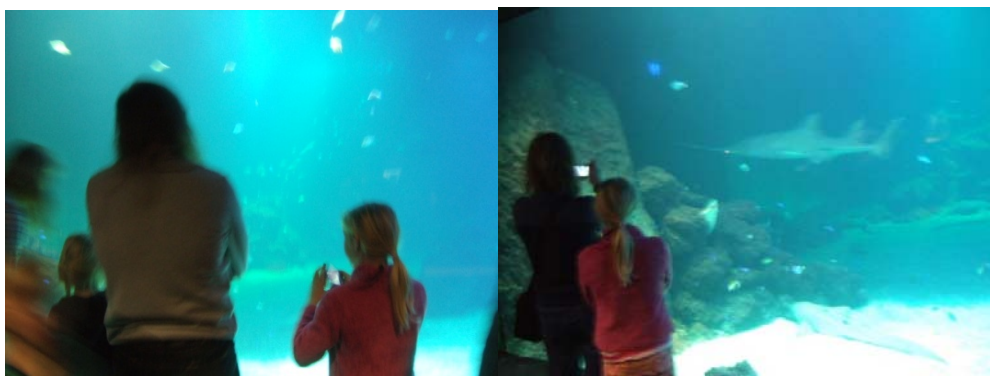


Figure 13. The girl and her mother were capturing photos in case 3.

Case 4: There were a boy A (10 to 11 years old), a boy B (7 to 8 years old) and a father in front of the ocean aquarium. Boy B pointed a fish to Boy A and they talked. While a shark was coming (big or small fish and saw fish), boy A chased it and captured some photos of it. He captured the sawfish, black tip shark and big shark. At the last time, it seems he captured a favorite one and showed it to his father.



Figure 14. The two boys were capturing photos in case 4.

Case 5: There were a girl (10 to 11 years old) with her grandmother, one baby and one younger brother (7 to 8 years old) in front of the ocean aquarium. She took lots of pictures of fish including some small fishes. After a while, they went away. On the way, she showed some pictures to her grandmother and explained something. At the same time her younger brother was trying to view the pictures in the girl's mobile phone (mobile phone was held by the girl).

- i. **Children are interested in viewing the photos captured by their classmates or other family members.**

Case 1: There was a mother with her son (around five or six years old) and her daughter (around 3 years old). The mother held a big camera and captured photos using it. Sometimes the mother helped the boy to take some photos using that camera. The boy could use the camera himself and took photos of fish in the ocean aquarium. After a while they sat on the bench in front of the ocean aquarium. The boy was quite interested in sharks. While a shark was coming close, he was exciting and asked his mother to take some photos of it. He also viewed the photos in his mother's camera for several times and checked the pictures. They were attracted by the big sharks. When a small shark was swimming close to them, they are very happy. When the sawfish was coming close, he pointed it to his mother too. He was always very happy when a shark or a big fish came close. At 10:26, they went away.



Figure 15. The boy and his mother were capturing photos in case 1.

From this case, the boy cannot manipulate the camera very well. However he is interested in photo some fish and view the images captured by his mother.

Case 2: A girl (around 3 or 4 years old) and her mother were in front of the ocean aquarium. The girl was very interested in some fish. Her mother took some photos using her mobile phone. Then the girl viewed the photos in her mother's cell phone (her mother held the cell phone). Then her mother took another some pictures for her. The girl and the saw fish were in the photos. Then the girl checked that photos too (the cell phone).

Case 3: There were a girl A (* 9 years old) with her mother and another girl B (* 8 years old), boy C (* 8 years old) and one baby with their mother. B and C are twins. The two mothers are friends.

B held a mobile phone. C pointed some fish to B. Then B prepared and manipulated the phone for several seconds to capture a photo. Several seconds later B took a photo. C came and viewed the photo in B's phone. While B was taking another picture, C was trying to view the screen of the B's phone at the same time to see what B was taking.

A came here and held a mobile phone and took lots of pictures. It seems A can use a mobile phone better than B. While A was taking the photos, B and C were trying to see the screen of A's mobile phone at the same time and wanted to know what A was taking and how the pictures were.

After a while, they went back to their mothers. B gave the mobile phone to her mother. It seems the B's cell phone is belonged to her mother. I asked A's mother about the age of these children.



Figure 16. The three children were capturing photos in case 3.

Case 4: *There were a girl (*10 years old), a boy (* 8 years old) and their mother in front of the ocean aquarium. The girl held a mobile phone. She was very interested in some small colorful fish in the aquarium. She tried to use her cell phone to take photos. She captured some. Sometimes the boy pointed some fish to the girl and then the girl took some photos. While the girl was taking the photo, the boy was watching the screen of the girl's mobile phone. I asked their mother and she said the both of them have mobile phones.*



Figure 17. The two children in case 4.

APPENDIX B

There is the questionnaire used in the evaluation of Fotofiske.


Fotofiske-enkät

Tack för att du har testat Fotofiske på din mobiltelefon! Det vore värdefullt om du ville svara på frågorna nedan. På så vis kan vi få idéer om vad du tyckte om speket och hur vi kan förbättra det i en eventuell framtida version.

Om det är en förälder som hjälper barnet att svara på frågorna, betyder "du" det barn som spelade Fotofiske.

1. Är du (användaren): ☐ vuxen ☐ barn ☐ ungdom
Om du är ett barn eller ungdom, hur gammal är du? _____
2. Hur många frågor besvarade du på den lätta nivån: Hajar och stora fiskar? _____
Hur många frågor besvarade du på den svåra nivån: Färgglada fiskar? _____
3. Har du lärt dig namnet på någon ny fisk eller haj, i så fall vilken/a? _____
4. Hur upplevde du spelet?
☐ mycket intressant ☐ intressant ☐ inte intressant
5. Hur tyckte du att spelet var att använda och förstå?
☐ enkelt ☐ svårt ☐ mycket svårt
6. Har du några andra idéer om hur Fotofiske skulle kunna bli ett roligare och bättre spel?

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APPENDIX C

There are additional cases in the evaluation phase of the thesis project.

Case 1: *there was a five years old boy with his father in front of the ocean aquarium. His father knew how to manipulate the application quite well. The boy visited Universeum several times previous. The father helped the boy to read the description and repeat the description some times. He needed his father to help him to manipulate the Fotofiske game some times. However the boy could use the Fotofiske and captured a good photo of the correct fish. He was enjoyed the game. However at last he thought the high level's game is quite difficult, and had no more enough patience to finish it. He answered 5 low level questions and 2 high level question answers. From this game he learned 1.5 fish. He thought the game is fun and difficult. And he wanted another game he could use to capture a photo of octopus.*

This case shows that the boy is enjoy this game if the fish is easy to find, as he want another game of black fish.

Case 2: *There was a 7 years old boy with his aunt sitting on the bench in front of the ocean aquarium. When the boy played the Fotofiske, he was smiling and seemed very interested in and enjoy in the game. The boy tried to find the fish which his aunt read the description for him. The boy captured a good picture of sågfisk and very happy and proud of his picture. However his aunt did not want to continue to do it. So we finished it.*

The boy's aunt helped the boy to read the questionnaire and wrote down the answer. The boy finished 1 question and learned 1 fish. He thought the game is very interesting and not difficult to use.